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Weather conditions and daily television use in the Netherlands, 1996–2005

Rob Eisinga · Philip Hans Franses · Maurice Vergeer

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Abstract This study examines the impact of daily atmospheric weather conditions on daily television use in the Netherlands for the period 1996–2005. The effects of the weather parameters are considered in the context of mood and mood management theory. It is proposed that inclement and uncomfortable weather conditions are associated with lower human mood, and that watching entertainment and avoiding informational programs may serve to repair such mood. We consequently hypothesize that people spend more time watching television if inclement and uncomfortable weather conditions (low temperatures, little sunshine, much precipitation, high wind velocity, less daylight) coincide with more airtime for entertainment programs, but that they view less if the same weather conditions coincide with more airtime devoted to information fare. We put this interaction thesis to a test using a time series analysis of daily television viewing data of the Dutch audience obtained from telemeters ($T=3,653$), merged with meteorological weather station statistics and program broadcast figures, whilst controlling for a wide array of recurrent and one-time societal events. The results provide substantial support for the proposed interaction of program airtime and the weather parameters temperature and sunshine on aggregate television viewing time. Implications of the findings are discussed.

Keywords Weather conditions · Television viewing · Human mood

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Introduction

It is well known that certain elements of the weather, foremost temperature and sunshine and the seasonal photoperiod, are important determinants of the annual cycle in overall levels of television use. TV viewers, on average, tend to watch more television during days with lower temperatures, less sunshine, and fewer hours of daylight. The seasonal variation in television viewing, peaking in winter and bottoming in summer, is found in the USA (Comstock et al. 1978; Gensch and Shaman 1980; Barnett et al. 1991) and across various European countries (Barwise and Ehrenberg 1988; Roe and Vandebosch 1996). The daily weather conditions that people are exposed to are significant in relation to television use, but the effect sizes may vary by season. Generally, the longer the photoperiod (i.e., the later it gets dark outside), the greater the effects of the weather parameters temperature and sunshine on daily television viewing time (Roe and Vandebosch 1996).

A biometeorological explanation of the weather impact is that inclement and uncomfortable weather conditions, especially relating to thermal and mechanical comfort, deter participation in outdoor leisure activities while promoting home-based, sedentary activities (Spinney and Millward 2010), most notably watching television. Also, researchers have hypothesized that weather affects people's emotional state or mood, which creates a predisposition to engage in particular behaviors (Howarth and Hoffman 1984). Human mood may thus mediate the relationship between weather and television viewing. Mood management theory proposed by Zillmann (1988) posits that the consumption of specific television program types is capable of altering mood states. The theory argues that people who suffer from lower mood typically refrain from exposure to informational programs, such as news and documentaries, and instead resort to the

consumption of entertainment programs, such as amusement and comedy, to improve their mood (Zillmann 2000).

The current study addresses this issue. It examines the simultaneous impact of inclement and uncomfortable weather conditions (low temperatures, little sunshine, much rainfall, strong winds, less daylight) and the broadcast of entertainment and informational type programs on daily television viewing time, using viewing data of the Dutch audience covering the years 1996–2005 ($T=3,653$). The paper conjectures that watching television is not only affected by weather and the programs being broadcast but also by their mutual interplay. It assumes that inclement and uncomfortable weather conditions manifest themselves in lower human moods and that entertainment broadcast may alleviate such moods. We therefore propose that, under inclement and uncomfortable weather conditions, TV viewing time may either increase or decrease depending on the broadcast on television of more entertainment or more informational programs, respectively.

The following section reviews the literature and specifies our hypotheses. The time series data and the model to analyze the data are discussed next. We subsequently present the empirical results and discuss our findings.

Theoretical considerations

The seasonal and meteorological nature of television viewing is typically explained by arguing that viewing competes for time with other leisure activities, and that people tend to watch less when the amount of daylight and the weather conditions permit them to be outside and engage in outdoor activities, especially warm weather out-of-home activities (Gensch and Shaman 1980; Gould et al. 1984; Roe and Vandeboosch 1996). Good weather helps people choose activities that they can do outdoors. If the weather conditions are nice, they take the time to go out, participate in outdoor physical activities, visit relatives or be on the go. Inclement and uncomfortable weather conditions in contrast, such as accumulated snow and a cold outside temperature, pose a barrier to leisure activity engagement by negatively influencing mechanical or thermal comfort (Spinney and Millward 2010). While adverse weather conditions pose an opportunity for some specific outdoor activities (e.g., high winds for sailing and temperatures below freezing for ice-dependent sports such as skating), it poses a mechanical barrier for many other outdoor activities and for travel to indoor leisure activities. Inclement and uncomfortable weather reduces the range of recreation and leisure opportunities, physical and social, and can act as a mechanical or perceived barrier for accessibility and mobility to out-of-home leisure opportunities, while promoting home-based and physically passive

leisure activities, such as reading and watching television. The latter is the world's most popular sedentary pastime. On average, individuals in the industrialized world devote more than 3 h a day to traditional TV—more than half their leisure time and more than on any single activity save work and sleep (Kubey and Csikszentmihalyi 2002). Thus, the purported annual cycle in television viewing is assumed to be due to by-products of the weather. These by-products are related to diminished opportunities for being outside, including restricted travel opportunities and limited participation in recreational and other outdoor activities.

Weather and changing weather conditions not only affect leisure activity engagement. They are also popularly believed to affect people's emotional state or mood (Persinger 1980; Watson 2000). Cold, cloudy and rainy days are typically considered to lower human moods whereas warm, sunny and dry days are taken to heighten their mood feelings. For some people, relentless rain and persistent grey skies may be depressive making the day feel long and tiring, especially when they would normally expect to be spending long warm days and evenings outside. Also, some population groups, such as the elderly, can be adversely affected by persistent precipitation, which makes it difficult for them to get out of the house, and can leave them feeling isolated and lonely, which may trigger a lower mood. Hence, inclement and uncomfortable weather is taken to be 'bad' weather, at least for certain activities, and bad weather is considered to make people feel 'bad'.

It should be noted that empirical research on the association between weather and human mood is limited and of mixed results. Several studies reported that mood is responsive to weather fluctuations and that high mood is associated with more sunshine hours (Persinger 1975), high levels of sunlight (Cunningham 1979; Parrott and Sabini 1990; Schwarz and Clore 1983), low levels of humidity (Persinger 1975; Sanders and Brizzolara 1982; Howarth and Hoffman 1984), high barometric pressure (Goldstein 1972), and high temperature (Cunningham 1979; Howarth and Hoffman 1984). Mood sensitivity to weather fluctuations in these studies proves to be modest, however. Also, some studies (e.g., Clark and Watson 1988; Watson 2000) found no significant relationship between mood and any of the assessed weather variables (sunshine, barometric pressure, temperature and precipitation). Recently, Denissen et al. (2008) examined the impact of six different daily weather factors (temperature, wind, sunlight, precipitation, air pressure, and length of day) and concluded that the average effect of 'good' weather on positive mood was minimal. Windy, cool, and darker days seemed to have just a slight negative effect on mood, with many people reporting that they felt tired or sluggish. The researchers strained to draw a final conclusion, however, and determined in the end that "people differ in their sensitivity to daily weather changes" (Denissen et al. 2008, p. 667).

This seems to corroborate the findings reported by Barnston (1988), who argued that psychologically troubled people are generally more susceptible to fluctuations in mood stemming from weather conditions than others. Also, the weather's impact on people's mood may vary by season. Keller et al. (2005), for example, found that moods do rise with higher temperature, but only in spring. And even during the spring, only people who spend time outside in the sun are likely to be measurably happier. These results are consistent with findings on seasonal affective disorder, a condition where depressions in fall and winter alternate with non-depressed periods in spring and summer (Rosenthal 2005), and suggest that pleasant weather (i.e., longer days with more sunlight) improves mood and broadens cognition in the spring because people have been deprived of such weather during the winter (Ennis and McConville 2004).

Several experimental studies have shown that people typically choose activities in such a way as to maintain good moods (Isen and Levin 1972; Isen and Simmonds 1978). Moreover, those in lower mood engage in various pleasure-producing activities to self-regulate their mood to comfortable levels or to keep them from getting worse (Morris and Reilly 1987; Thayer et al. 1994; Parkinson et al. 1996). One possible device for self-regulating mood is distraction, i.e., the redirection of attention away from some disturbing stimulus, and one of the most readily available sources of distraction and escape in modern society is watching television (Morris and Reilly 1987; Thayer et al. 1994).

This conjecture ties in well with mood management theory proposed by Zillmann (1988). His theory posits that television consumption is capable of altering mood states and that the selection of specific media content categories for consumption serves the optimization of mood. According to mood management theory, entertainment programs bring about mood change more effectively than do information programs (Zillmann 1988). People who suffer from lower mood therefore typically refrain from exposure to informational programs such as news and documentaries and resort to the consumption of entertainment programs, such as comedy, as it makes them feel better (Anderson et al. 1996; Zillmann 2000). Mood management through television consumption is most apparent in situations where people have little influence over the conditions that foster lower moods, such as poor weather conditions. Individuals who cannot alter the circumstances that put them in lower moods are likely to choose mood enhancers such as cheerful entertainment programs (Zillmann 1988). They, so to speak, watch their troubled moods away (Moskalenko and Heine 2007).

Taken together, we propose a specific interaction between weather and program content and its effect upon television viewing time. We assume that inclement and

uncomfortable weather conditions manifest themselves in lower human moods. People who suffer from such moods turn on the television to cheer themselves up and seek appropriate positive stimuli in the television program offerings available to them (Finn and Gorr 1988). They typically turn to entertainment as it holds greater promise of improving such mood than do informational programs. We therefore hypothesize that people spend more time watching television if inclement and uncomfortable weather conditions (low temperatures, little sunshine, much precipitation, strong winds, little daylight) coincide with more broadcast time for entertainment programs (i.e., amusement, fiction, sports, children's television, and music). Relatedly, we also predict that they spend less time watching television if the same weather conditions coincide with more broadcast time for informational programs (i.e., news, serious information and education).

To test these hypotheses, we use aggregate time series data on daily television viewing time of the Dutch audience. Given the aggregate data available to us, we are unable to empirically examine the mediating role of human mood in the effect of weather on television viewing. Instead, mood and mood management theory are used as a heuristic tool to link weather and program airtime to particular changes in TV viewing time. We test the value of this theory and the efficacy of the predictions it provides.

In addition to annual peaks and valleys in television viewing, there are other significant cycles and trends. In the Netherlands, as in many other countries, viewing peaks on Sunday and hits bottom on Thursday (Peeters et al. 2005), and under normal conditions, this weekly pattern is repeated over time. The intra-weekly cycle is the result of social factors affecting the demand for television, such as the amount of leisure time, but it is also partly due to television itself (Gensch and Shaman 1980). The horizontal programming by network schedulers requires viewers to watch television series and programs at fixed 7-day time slots. Moreover, the amount of broadcast airtime has a cyclic pattern too, with lower amounts of daily airtime on weekdays compared to the weekend, and most broadcast airtime transmitted on Sunday. The same supply and demand effects cause viewing time to peak on national holidays and breaks and on special occasions when one-time happenings or recurrent (e.g., sports) events take place. Also, the television program content cycle in network scheduling has an annual cycle in that attractive new programs (popular series and films) are broadcast in fall and winter, and less attractive end-of-season older programs (repeats and reruns) in spring and summer. Finally, there is a secular upward trend in television viewing time over the years due to, amongst others, the increase in channels and platforms and the resulting expanded range of television airtime, the increase in leisure

time, the diffusion of television technology innovations, and the alteration of everyday use of time. The model we use in this study takes these cyclical patterns, high viewing days and upward trend into account.

Data and model

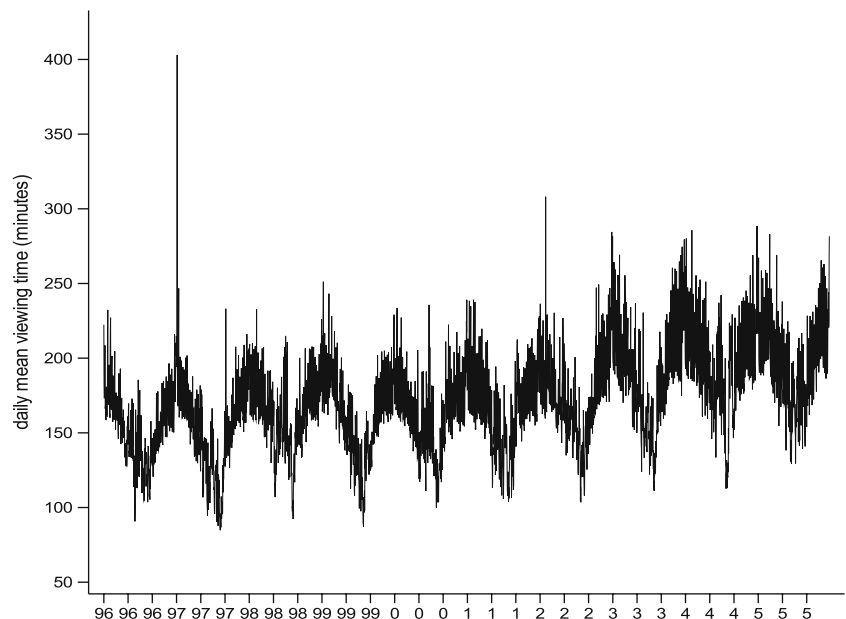
The analysis presented here uses Dutch television viewing figures and official weather statistics, matched with data on various societal events. The viewing time statistics are based on telemetric viewing data obtained from an audience panel maintained by GfK Intomart for the SKO (Stichting KijkOnderzoek), the main provider of telemetric viewing data in the Netherlands. The panel has about 1,240 households with about 2,700 individuals and is taken to be representative of the Dutch population aged 6 and over (Peeters et al. 2005). The dependent variable is *daily mean viewing time* of the average household recorded in minutes per television day (i.e., 2.00 am to 2.00 am next day) and covers a period of 3,653 days from 1 January 1996 to 31 December 2005. The variable registers the amount of time actually watched and not, for example, the time television sets are turned on. The measurement is restricted to the audience of the major Dutch television channels and excludes special interest networks. The leading channels have a total market share of approximately 80% and they broadcast a wide range of television programs aimed at the Dutch language audience. Excluding 2 days with exceptionally high viewing figures (i.e., 4 January 1997 and 2 February 2002), daily mean viewing time ranged from 84.8

to 288.5 min, with a mean of 169.2 (SD 31.3). Figure 1 displays the day-to-day variation in viewing time over the 10-year data collection period.

The series has both a seasonal pattern, reaching its maximum at the turn of the year and minimum in week 31 (i.e., when July turns into August), and an upward trend, increasing from an average of 152.9 min in 1996 to an average of 194.6 min in 2005. The seasonal variations, with peaks about 23% higher than the annual average and troughs 26% lower, are seen to be much larger than the year-to-year shifts of approximately 4%. A visual inspection of the plot also indicates that there are many aberrant days with large amount of viewing time. Most obvious are 4 January 1997 (403.0 min)—when all day live coverage of the Frisian 11-cities ice skating tour started at the break of day—and 2 February 2002 (308.1 min)—when many Dutch citizens were watching the wedding ceremony of Prince Willem-Alexander and Princess Maxima on live television.

The official weather statistics for the Netherlands were obtained from the Royal Dutch Meteorological Institute, based on daily observations of ten weather stations across the country for the period 1996–2005. The measurements used here concern the 10-weather-station averages and include daily mean *temperature* in degrees Celsius, the fraction of maximum possible *sunshine* duration in percentages, the daily mean *wind velocity* in meters per second, and the daily *precipitation* amount in millimeters. The daily mean outside temperature ranged from -12.1 to 25.8°C (10.3 – 78.5°F) with a mean of 10.3°C (SD 6.2). The fraction of maximum possible sunshine duration ranged from 0 to

Fig. 1 Daily mean television viewing time 1996–2005 (minutes per day)



93.3%, with a mean of 36.3% (SD 26.2). The daily mean wind velocity ranged from 1.3 to 13.2 m/s (mean 4.5, SD 1.9) and daily precipitation had a range of 0 to 31.8 mm (mean 2.3, SD 3.5). In addition, *photoperiod* was obtained as the time from sunrise to sunset in minutes, using the geographical center of the Netherlands as reference point. Whereas sunshine taps day-to-day fluctuations in the weather, photoperiod is determined by calendar date and latitude. Photoperiod ranged from 584 to 1,124 min (mean 856, SD 184) per day. The variable included in the analysis is photoperiod divided by 60.

To examine the effects of program type broadcast, the analysis includes the daily *program type duration* using data collected by MediaXim. The complete range of program categories was divided into two program types: informational programs (i.e., news, serious information and education programs) and entertainment programs (i.e., amusement, fiction, sports, children's television and music). We computed the duration of the two program types in minutes per day for all channels taken together. The *number of channels*—rising from 7 in 1996 to 10 in 2005—is used as a control variable as it affects the total amount of airtime. Daily program type duration potentially ranges from 0 to 14,400 (24 h \times 60 min \times max. 10 channels) min. Informational program duration ranged from 845 to 6,475 min (mean 2,947, SD 872) and entertainment had a range of 1,980–6,241 min per day (mean 3,605, SD 666). Hence, during the period 1996–2005, the menu of an average television day had 44% informational and 56% entertainment programs. Obviously, some single days were strongly dominated by entertainment and others by information broadcasts. As an example of the latter, on 11 and 12 September 2001, informational programs reporting on the World Trade Center attack occupied more than 74% of the total airtime of all (at that time 9) channels taken together. There are intra-week and intra-semi-annual variations in the airtime of some program categories. Saturday is a top broadcasting day for information and Sunday is a weekly peak for sports and music entertainment. A top broadcasting day for sports entertainment is when, on a Sunday, different games or major tournaments take place simultaneously. Also, the airtime of informational programs has a semi-annual cycle, reaching its lowest points in January and July and its highest points in April and October/November. This cyclic pattern is a mirror image of the seasonal variation in entertainment airtime.

During the decade considered here, various regular and irregular, one-time and recurrent *societal events* occurred that had a substantial effect on the amount of television viewing. Based on a preliminary analysis of the television viewing data, 58 (1-day and multiple-day) event variables were designed using various data resources (e.g., printed and electronic newspapers, yearbooks, and encyclopedia).

An overview of the events is presented in [Appendix](#). Altogether, the variables register a total number of 1,912 events that may be categorized into sports (87.8%), national holidays and breaks (5.2%), social, cultural and natural events (3.8%), Dutch Royal house events (1.6%), deaths and funerals of celebrities excluding Royal house (0.7%), political (0.4%) and media-related events (0.3%). The 1,912 events occurred on 1,538 days (42.1%), and the annual number of events ranged from 138 (2003) to 164 (1998 and 2000), with a mean of 154 (SD 9) events per annum.

The time series regression model we use has a linear deterministic time *trend* term t , divided by 1,000, to capture the upward secular trend in viewing and the time harmonic regressor variables $\cos 2\pi t/n$ and $\sin 2\pi t/n$ to capture intra-year ($n=365$), intra-semi-annual ($n=183$), and intra-week ($n=7$) variations. The model includes interaction terms of the weather variables (excluding photoperiod) and the annual harmonic variable, as the weather effects are supposed to be smaller in the winter than they are in the summer. It also includes interaction terms of program duration and the intra-semi-annual and intra-week harmonic variables, as the effect of program duration may vary across day of the year and day of the week. To examine the interplay between weather and program type broadcast, we include interaction terms that relate elements of the weather to the duration of entertainment and informational broadcast. For example, we incorporate the interaction variable *temperature \times entertainment* program. Terms were added to incorporate the effect of TV viewing the day before three high viewing days (i.e., Queens Day on 30 April 30 (except 29 April 2000), the Frisian ice skating tour on 4 January 1997, and the Royal wedding ceremony on 2 February 2002), and the day after the daylight saving time start date and the World Trade Center attack on 11 September 2001. Finally, the regression model includes lags of the dependent variable daily mean viewing time. They are incorporated because television habits are rhythmic and consist of viewing patterns that are repeated over time. Based on time series diagnostic tests, we added 14 autoregressive terms, labeled *routine viewing*, implying that TV viewing time is affected by people's viewing behavior during the past two weeks.

Analysis and results

Four sets of variables are proposed to explain the process that moves viewers through the aggregate annual cycle: deterministic terms, routing viewing, weather and program type duration. To examine the main effects of these variables a regression model was applied to the data, excluding the interactions of weather, program type duration and seasonality. The results are presented in Table 1.

Table 1 Parameter estimates of deterministic terms, routine viewing (selected autoregressive lags), weather and program type duration (divided by 60) in model including societal events but excluding weather-program type duration interaction terms (adjusted $R^2 = .900$)

	Unstandardized		Standardized
	Estimate	Standard error	Estimate
Deterministic terms			
Intercept	92.306*	5.333	
Trend ($t/10^3$)	7.832*	.578	.260
$\cos 2\pi t/183$	-2.308*	.282	-.051
$\sin 2\pi t/183$	-.194	.253	-.004
$\cos 2\pi t/7$	3.840*	.488	.086
$\sin 2\pi t/7$	-2.639*	.467	-.059
Routine viewing (selected autoregressive lags)			
Viewing time yesterday	.262*	.013	.262
Day before yesterday	.054*	.012	.054
Same day 1 week ago	.245*	.013	.244
Same day 2 weeks ago	.162*	.012	.161
Weather			
Temperature	-1.039*	.053	-.203
Sunshine	-.159*	.007	-.132
Precipitation	.573*	.056	.064
Wind velocity	.826*	.101	.051
Photoperiod	-.433*	.093	-.042
Program type duration			
Entertainment	.318*	.033	.111
Informational	.074*	.027	.034

Societal event parameters are not reported. The annual harmonic variables are not included in the model as $\cos 2\pi t/365$ is almost perfectly correlated with the solar photoperiod (Pearson's $r = -.989$)

* $p < .01$

The estimates of the deterministic terms indicate a steady upward trend in daily mean viewing from 1996 onwards and the presence of both a semi-annual and a weekly cycle. As can be seen, TV viewing is strongly affected by yesterday's viewing and the amount of time watched 1 week and 2 weeks ago. This finding corroborates the assumption that people tend to develop television program loyalty and a preference for particular programs in a given time slot. The four meteorological variables included in the model and the seasonal photoperiod all have a statistically significant effect on TV viewing time. Consistent with previous research in other countries, viewers tend to watch more television if the days get colder, cloudier and wetter, the winds stronger and the nights longer. Although the weather variables and seasonal daylight all significantly affect television viewing, according to the standardized regression coefficients shown in Table 1, the most important meteorological variables promoting sedentary TV time are outside temperature and the amount of sunshine reaching the earth. The colder the temperature and the less the sun shines, the longer the Dutch audience watches television. Also, the more airtime allotted for broadcasts in general, and entertainment programs in particular, the more time people spend watching television. Together the variables incorporated in the main effect model, including the social

event indicators, explain a substantial proportion of the variation in daily television viewing (adj. $R^2 = 0.900$).

To further examine the importance of the predictor variables, the drop in R^2 value was obtained when a variable or set of variables is omitted from the reference model. The full model including interaction terms was used as reference model for the variables comprising societal events, routine viewing and trend. For weather, seasonality and program type duration the reference model excluded the interaction terms of the variable involved. The findings, sorted by drop in R^2 value, are shown in Table 2.

As can be seen, the most substantial reductions in R^2 occur when removing the variables societal events, routine viewing and weather. The removal of the (58) societal event variables from the full model is accompanied by the largest drop in model fit, reducing the overall adjusted R^2 by 6.76% from 0.915 to 0.853. Marked drops in R^2 also occur if routine viewing behavior (i.e., the set of 14 autoregressive lags) and the weather parameters (temperature, sunshine, precipitation and wind velocity) are excluded from the regression model. The latter finding supports the thesis that sedentary television viewing habits are strongly affected by the weather. From a statistical model fit perspective, the fourth most important set of variables concerns the interaction of weather and program type duration. This result supports the suggestion that

Table 2 Percentage drop in adjusted R^2 if terms are omitted from reference model^a

Terms	Adj. R^2 reference model	Adj. R^2 if terms omitted	% Δ
Societal events	.915	.853	6.76
Routine viewing	.915	.876	4.22
Weather	.907	.869	4.13
Weather \times program type duration	.915	.909	.60
Trend	.915	.911	.48
Weather \times intra-year seasonality	.915	.911	.42
Intra-week seasonality	.912	.908	.41
Program type duration \times intra-week seasonality	.915	.912	.37
Program type duration	.907	.904	.31
Intra-year seasonality	.909	.908	.12
Program type duration \times intra-semi-annual seasonality	.915	.915	.05
Intra-semi-annual seasonality	.915	.914	.02

^a Reference model is either full model or model excluding interaction terms

watching television is not only affected by weather and program broadcast but also by their mutual interplay. The simultaneous impact of weather and program type duration is even more important than trend and seasonality in explaining aggregate viewing time. Table 3 presents the parameter estimates of the weather and program type duration interactions.

The most substantial interactions involve the weather variables temperature, sunshine and wind velocity. The figures indicate that the negative effects of temperature and sunshine on TV viewing and the positive effect of wind velocity increase with increasing airtime allotted to entertainment. This finding, conversely, implies that the daily mean viewing time of the average Dutch household increases if the days get colder, cloudier and windier and that this increase becomes larger with increasing amounts of airtime allocated to entertainment. The significant

interactions of temperature, sunshine and the duration of informational television programs turn out to be positive. This indicates that the more airtime allotted to informational programs the larger the increase (decrease) in television viewing time if the days get warmer and sunnier (colder and cloudier). Together, these findings may be taken as indirect evidence in support of mood management theory. If the weather conditions deteriorate, people increasingly resort to the consumption of entertainment programs and refrain from exposure to informational programs, to improve their weather-induced lower moods or to keep them from getting worse.

To explore the differences in TV viewing, we obtained the fitted values of daily viewing time for selected values of temperature (in °C) and program duration (in min), holding the other variables constant at their means. Table 4 gives the results.

Table 3 Parameter estimates of weather (including photoperiod) and program type duration (divided by 10^3) interactions

Weather	Program type	Unstandardized		Standardized
		Estimate	Standard error	Estimate
Temperature \times	Entertainment	-.277*	.064	-.214
	Informational	.205*	.049	.129
Sunshine \times	Entertainment	-.083*	.011	-.260
	Informational	.032*	.008	.089
Precipitation \times	Entertainment	-.082	.083	-.034
	Informational	.076	.070	.026
Wind velocity \times	Entertainment	.418*	.146	.100
	Informational	-.221	.118	-.050
Photoperiod \times	Entertainment	-.089	.133	-.042
	Informational	-.046	.104	-.021

* $p < .01$

Overall, people tend to spend more time watching television if the outside temperature decreases. If temperature drops from 20 to -10°C and entertainment broadcast comprises 2,000 min, the average daily viewing time increases about half an hour from 146.1 to 176.4 min. This increase in TV viewing is substantially larger, namely almost 1 h, if 5,000 airtime minutes are allotted to entertainment. Hence, people spend more time watching television if decreasing temperatures coincide with larger amounts of entertainment broadcast. Things are quite different, however, when it comes to informational broadcast. There is hardly any difference in viewing time (1.4 min) if the temperature drops from 20 to -10°C and relatively little airtime (2,000 min) is devoted to information. However, if 5,000 airtime minutes are allotted to informational broadcast and temperature drops from 20 to -10°C , viewing time decreases by about 20 min, from 180.3 to 163.2 min per day. This implies that people spend less time watching television if decreasing temperatures coincide with a large amount of broadcast time allocated to information. Also, as can be seen Table 4, if temperatures are low (i.e., -10°C), daily viewing time increases if larger amounts of airtime are allotted to entertainment. It decreases however, albeit slightly, if more airtime is allotted to information. Altogether, the findings presented here strongly corroborate our hypotheses, based on mood management considerations. If the weather conditions deteriorate, people tend to spend more time watching television if a larger share of the airtime is devoted to entertainment. They fail to do so and even tend to watch less television if exposed to more information fare. While the analysis presented here does not directly speak to the question why television viewing should behave in this fashion, at the outset we offered a theoretical explanation

for this particular pattern. This explanation leads to the suspicion that the relationship between weather and viewing behavior is mediated by human mood. Inclement and uncomfortable weather is associated with lower human moods and entertainment programs brighten such moods, more than does information fare.

Conclusion and discussion

This study investigated the effect of various weather measures on television viewing time in the Netherlands for the period 1996–2005. Rather than hypothesizing a direct relationship between weather and TV viewing, this paper attempts to clarify a mechanism that may underlie the relationship via the inclusion of human mood. Several biometeorological studies have related weather to mood (Keller et al. 2005, Denissen et al. 2008), and various communication studies have suggested a link between mood and media consumption (Zillmann 1988, 2000). The theoretical perspective that guided the study was that cold, cloudy and rainy days lower human mood and that people in lower mood prefer to watch entertainment programs rather than informative ones. In accordance with these considerations, it is proposed that viewers spend more time watching television if inclement and uncomfortable weather conditions coincide with more airtime for entertainment programs, and that they view less if these weather conditions coincide with more information fare. Our empirical findings support this proposition.

Given our results, behavioral assumptions about how viewers determine when they will watch television may require a subtle change. In models dominated by activity considerations, it is generally assumed that viewers first decide whether they are interested in watching television at a given time rather than engage in outdoor or other indoor activities and subsequently select a TV program on the basis of its content (Gensch and Shaman, 1980; Barnett et al. 1991). Models dominated by program content considerations typically assume that viewers first select a program and then organize their non-television activities to permit viewing when the program is broadcast. The findings presented here suggest that the decision-making process which underlies sedentary television viewing is a function of both alternative activities strongly dominated by the weather and TV content. Also, the weather–program interactions indicate that viewers are not passive acceptors of telecasts and that they respond both positively and negatively to program types in terms of viewing time according to biometeorological circumstances.

This research has shown that people spent more time watching television during the winter months than in

Table 4 Predicted daily mean viewing time (in minutes) by temperature (in $^{\circ}\text{C}$) and program type duration (in minutes)

Temperature ($^{\circ}\text{C}$)	Minutes		
	2,000	3,500	5,000
Entertainment			
20	146.1	154.7	163.2
10	156.2	169.0	181.7
0	166.3	183.2	200.1
-10	176.4	197.4	218.5
Informational			
20	166.4	173.4	180.3
10	166.9	170.7	174.6
0	167.3	168.1	168.9
-10	167.8	165.5	163.2

summer, lending credence to the assertion that watching television is in large part a default free-time activity, chosen when other options are unavailable. The study fits nicely with a number of biometeorological studies published over the past several years, suggesting that weather conditions and day length can promote or deter daily physical activity levels and sedentary behavior (Sumukadas et al. 2009; Spinney and Millward 2010). The declines in television viewing from winter to summer are likely to be balanced by higher levels of involvement in outdoor physical activities (Plasqui and Westerterp 2004; Tucker and Gilliland 2007; Sumukadas et al. 2009). For many people, watching television is the predominant leisure-time sedentary behavior, characterized by physical passivity. The effects of physical passivity are evident in the consistent finding of a relationship between quantity of TV time and, for example, diabetes and obesity (Hu et al. 2003; Kaur 2003; Foster et al. 2006) and death from cardiovascular disease (Dunstan et al. 2010; Wijndaele et al. 2010). These epidemiological studies emphasize the importance of reducing prolonged TV viewing (exposure to television and other recreational screen time), in addition to advocating physical activity, to prevent chronic heart disease and to reduce obesity and diabetes. The current study suggests that finding ways to ameliorate the impact of adverse weather conditions may be a fruitful way of reducing sitting time and boosting daily activity levels in people. Obviously, it is not possible to change the weather,

but providing indoor leisure facilities including transportation links during the cold and wet months may foster regular physical activity behaviors year-round.

Among its strengths, this study offered a rigorous test of a robust weather–television program interaction effect on viewing time, using a time series of daily viewing data covering a 10-year period, controlling for a wide array of other variables. Obviously, the study also has limitations. An important one is that it is not possible to ascertain from our data whether weather variability is predictive of human mood. Our conclusions are based on the analysis of aggregate data and there is certainly a need to deliver individual-level evidence for the proposed relationships between weather, mood regulation and television viewing habits using micro-data studies. Such studies may also consider other factors to explain why entertainment fare is of greater interest during cold and cloudy weather. For instance, there may also be a social aspect at work, rather than a psychological one, that leads people to get together with family or friends and watch entertainment television together during unpleasant weather simply as a means to congregate.

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Appendix

Table 5 Variables used to register (1,912) societal events in the 1996–2005 period

National holidays and breaks (100):	Christmas Eve, New Year's Eve, New Year's Day, Easter Sunday, Easter Monday, Ascension Day, Good Friday, Whit Sunday, Whit Monday, Queens Day
Social, cultural and natural events (72):	Mardi Gras, Memorial Day, arrival Saint Nicholas, Eurovision song contest, domino day, Frisian 11-cities ice skating marathon, weather alarm, start and end date daylight saving time, solar eclipse
Royal Dutch house events (32):	Wedding day Prince Willem-Alexander and Princess Maxima, funerals of Prince Claus, Princess Juliana and Prince Bernhard, Royal family birth, other weddings, jubilee, broadcasted interviews, other royal family events
Death and funeral of celebrities (excluding Royal Dutch family) (14):	Death Diana Princess of Wales, funeral Diana Princess of Wales, death Dutch celebrity, funeral Dutch celebrity
Political events (8):	Dutch national election second chamber, fall Dutch government, visit US president Bush to the Netherlands, arrest Saddam Hussein, 9/11 2001 WTC attack
Media-related events (6):	Fifty years Dutch television, Live8, major TV aid programs
Sport events (1,680), including soccer (1,335), cycling (168), ice skating (83), other Olympic games (84), darts (10):	Number of soccer matches in national league, home/abroad national league match between Ajax, Feyenoord and PSV, number of soccer matches in national cup, home/abroad national cup match between Ajax, Feyenoord and PSV, national soccer cup final, Dutch national soccer squad A matches, Dutch national soccer squad world cup qualifications, Dutch national soccer squad world cup finals, Dutch national soccer squad euro cup qualifications, Dutch national soccer squad euro cup finals, UEFA champions league/cup final, number of matches at FIFA world cup and UEFA European football championships, summer Olympic games, winter Olympic games, winter Olympic games skating, winter Olympic games skating men, Tour de France mountain stage, classic road cycle races UCI world cup, road cycle race world championships men elite, skating world all-round championships men and women, skating European all-round championships men and women, world darts championship Embassy/Lake Side

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